ECONOMIC DEVELOPMENT AND INFRASTRUCTURE COMMITTEE

Inquiry into Mandatory Ethanol and Biofuels Targets in Victoria

Melbourne — 27 August 2007

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The CHAIR — Welcome to the public hearings of the Economic Development and Infrastructure Committee Inquiry into Mandatory Ethanol and Biofuels Targets in Victoria. All evidence taken at the hearing is protected by parliamentary privilege. Comments you make outside the hearing not afforded such privilege. Could I ask you please to state your name, if you are representing an organisation, what organisation that is, and your position and address.

Prof. SPANGENBERG — My name is German Spangenberg. I am Research Director of the Molecular Plant Breeding CRC Research Centre and Research Director for Plant Genetics and Genomics with the Victorian Department of Primary Industries. I am based at the Victorian AgriBiosciences Centre at La Trobe University in Bundoora.

The CHAIR — Thank you. You have roughly 20 minutes to present a few points you want covered.

Prof. SPANGENBERG — The key points I wanted to present is a range of technologies that would assist in the context of the development of bioenergy in the form of feedstocks for cellulosic ethanol production from non-food sources. The document that is distributed makes in a sense the case for the challenges and the energy challenges on page 3 in Victoria and the consequences of that — the need to bring science to contain greenhouse gas emissions in the supply and use of energy to develop over time a sustainable energy sector and in line with that the rationale on a global basis for the development of bioenergy.

The second point — I think the key points are actually on the top of page 4, slide no. 7 — is the need to follow a long-term strategy of decoupling biofuel from food industries in the context of a next generation of biofuels that will need to come from non-food sources in order not to create market distortion associated with food and feed. These are likely to be produced from dedicated bioenergy crops or produced from by-products of other human activities, specifically from the fermentation of crop residues of cereal straw or grass biomass. That is the core aspect of that. I understand that the opportunity to present here was based on outlining some of the technologies that are being developed in the context of the Victorian Department of Primary Industries, as well as the Molecular Plant Breeding Comparative Research Centre that could contribute towards that goal.

In a sense today we see almost half of the global biomass of crops wasted in the form of straw; that is 2 billion tonnes globally. We can almost look at opportunities for Australia to generate approximately 40 million tonnes of cereal straw residues, and that potentially has the capacity to create in excess of 15 billion litres of bioethanol. On the other hand the bio-degradation of cellulose and hemicellulose of cereal straw is heavily prevented by lignin — these are waterproof cell walls that prevent fermentation.

On the next page, page 5, there is an outline of the critical issues for cellulosic ethanol — in production of biomass, in quantity and quality — in context of the fermentability of doing so in a sustainable manner. The following page — I think particularly slide no. 12 on page 6, shows a range of technologies which — certainly in the first two of these categories — we are working on at present. The first of these is modifying cell walls in order to assist with the deconstruction — that is, the fermentability of cellulose — by altering lignin content and composition and cleavability, by reducing the cross-links and also by replacing the polysaccharides. We have over the last years worked on developing a range of such technologies. The basis for those are outlined in the following pages, and these are shown as examples for a greener grass. The more red — you will see these images on slide 14 — —

The CHAIR — Sorry, can I just ask you to speak up a little bit, if you do not mind, and given you are using a number of scientific and biological terms — —

Prof. SPANGENBERG — Yes, to explain those.

The CHAIR — It would be good if you spoke up louder so they register, and particularly if you refer to the slides, it will assist. Thank you.

Prof. SPANGENBERG — Okay, yes. Referring to slide 12 it is the one that highlights the core areas of technologies for feedstock for cellulosic ethanol production from non-food sources. The first point is technologies that are based on modifying cell walls to make them more accessible and more fermentable. In particular the key element there is altering lignification. Lignin waterproofs cell walls and makes them as a consequence not accessible, but energy for fermentation.

The following slides, 13 and 14 on page 7, show that basically lignin is deposited along the development of the grass or the cell — or a cereal straw to be exactly the same. What we see is the more red in those images, the more lignified they are. These are cross-sections through a stem, and everything that is red there is non-fermentable. On page 8, on slide 16, we show the proof of that. So we take those cross-sections, and we glue them in rumen liquid, rumen fluid, the way it would be fermented by a cow, and we see that everything that was red remains after 48 hours undigested. On page 9 — —

The CHAIR — 'Digested' or 'undigested'?

Prof. SPANGENBERG — Remains undigested. It remains there after 48 hours — you see that everything that was white on the image at time point zero has disappeared, becomes a hole in 40 to 48 hours, but everything that was red at the time point zero remains red. Basically 25 per cent of the cell walls are not used. The rationale behind the Department of Primary Industries developing these technologies was to enhance herbage quality for animal production for the dairy industry, but the same technologies can now be applied for making use of cereal straw or dedicated bioenergy perennial grasses for bioenergy production.

The proof of the concept of that is outlined in slide 18. The first technology is basically a technology to modify cell walls. It could be applicable to wheat straw or to perennial grasses. We see the image then on the GM grasses with reduced levels of two of the enzymes involved in the production of lignins, but you see that they are less red than the controlled ones. So we would expect that biomass to be already fermentable, contributing then to enhanced animal production if we use it as feed and to be fermented in a bioreactor for bioethanol to produce more energy. That is the first group. Slide 19 is the same one that we have seen before.

Moving to the second point, which is on the other slide, not only is it about producing more fermentable biomass but also to producing that in a sustainable manner with enhanced biomass yield and allowing for vegetative growth patterns that allow provision of that feedstock to a bioenergy plant. Slide 20 shows one technology that we have developed within the Department of Primary Industries for optimising and enhancing biomass. The proof of concept is illustrated there for white clover. We are interested in taking this technology now and applying it to wheat and other crops. On page 11, slide 21, the top slide shows basically the core of this technology that allows for yield enhancement in both seed yield and biomass, and while the proof of concept at present is in white clover, we want to extend it, as I indicated, to wheat and to — —

The CHAIR — I am sorry, I cannot hear you.

Prof. SPANGENBERG — We have demonstrated already the application of the core technology in white clover, a legume, but we now want to expand that technology and apply it to wheat as well as to other crops. So in the context of the presentation I wanted to present opportunities for enhancing biomass, seed yield and grain for food, while the biomass is for fermentation.

Slide 22 highlights the point of increasing the resistance to pests and diseases and making them more drought tolerant — so biotic and abiotic stresses. On the following page, page 12, in the bottom slide, we are assessing wheat for the expression of different genes for conferring drought tolerance. This is the first field trial. This is GM wheat established in Horsham and Walpeup. They are opportunities for enhancing biomass and production with less water.

Slide 26 on page 13 is an example of approaching it for enhancing disease resistance. There again, as indicated, are the annual losses we have in diseases in wheat and the opportunities for deploying technologies. We have tested and shown an example of that, slide 27, which is the fourth technology that we are developing. That is to achieve enhanced fungal disease resistance in wheat. The example you see there is for very different pathogens. The last point I wanted to make is looking at ways of producing that biomass in a nutrient-use efficient manner and requiring less fertilisers. It is being able to do it sustainably not only from the perspective of limited resources such as water but also from low input in the context of not requiring an application, or a reduced application, of fungicides to make it efficient in the context of both nitrogen and phosphorus — so fertiliser-use efficient.

On page 15 I show examples of technologies that we are developing for enhancing nutrient-use efficiency. The examples specifically shown there are for white clover, but we intend to apply the same technologies to other crops.

In summary, there are a range of technologies that are currently in development that could assist in different stages in the process of the sustainable bioenergy production from the perspective of developing bioenergy crops as well as agricultural residues without competing for, neither arable land nor for food and feed. That is basically it.

The CHAIR — Thank you very much. For someone whose science went to physics and chemistry in year 12, it is quite a challenge to understand the content of these slides. All I can say is that I am glad I have at least got that much science education. In terms of the key point of the long-term strategy for decoupling the biofuel and food industries, what would it be? What would be the key point in this presentation that you would make? I found this very interesting, but I am trying to work out what is the key point in this very interesting submission.

Prof. SPANGENBERG — The first key point is that a sustainable bioenergy sector will require the uncoupling of the two entities.

The CHAIR — You are the first person who has actually said that as clearly as you have.

Prof. SPANGENBERG — Uncoupling basically means in order not to distort the market and the price of food and feed. That is almost more a philosophical view about that. I am mindful that the demand for energy is almost unlimited. Therefore establishing policy frameworks that would drive bioenergy production, if it competes with food and feed, I think will create significant problems.

Mr THORNLEY — There was a gap in the middle that I am trying to grasp. I thought those global points that you made were very profound and very valuable. Then we got very quickly into a very detailed discussion about a range of technologies that may improve efficiency in a number of ways, whether it is through the genetic modifications, the changes to the lignum content et cetera. It is the part in the middle that I feel we are missing the context, which is: okay, I get that cellulosic ethanol has the potential to fundamentally address the fundamental challenge we have with biofuels, which is to decouple from food; I get that it is made from these materials, from the native grasses and other things; and then very quickly we are into, 'Here is what we would need to do to improve the operation' and it leaves a big question in the minds of me and, I think other Committee members, which is, 'Where is cellulosic ethanol production at now? What are the key barriers to cellulosic ethanol production being commercial and at industrial scale?'. It then sounds like, in response to some of those key barriers, you are doing some research that addresses them, but we are missing the context that is setting your research priorities.

Prof. SPANGENBERG — The first point is the position of looking at a long-term strategy of decoupling it. The consequence of that is that we need to look into lignocellulosics and there are constraints for that, so we need to do it economically and we need to ensure that the consequence of that is a need of, firstly, looking at lignocellulosic residues of zero value or the waste value to date, because that would create a good starting point to make it economically viable. The second point is that we need to enhance the energy value of that lignocellulosics, and what are the celluloses that contributes energy, and the ligno side is what prevents it. And therefore we need to develop and apply technologies that modify lignification.

Mr THORNLEY — Can I ask: there is currently some cellulosic ethanol technologies but they are very uncommercial in terms of their efficiency; is that where we are at now? The technical-risk issues are overcome and we can produce cellulosic ethanol, but just not in any way commercially effectively? Is that where we are at — you will pardon my ignorance about not knowing where this business is at.

Prof. SPANGENBERG — No, I would describe it as: those are the improvements required for, firstly the definition of the bioenergy crops to utilise for lignocellulosics; and secondly, requires technological deployment. And some of the technologies that we are developing contribute towards that. Today we will see primarily ethanol produced, say from a sugar or starch, and we will want to take it from lignocellulosics that has requirements for technology development and technological implementation.

The CHAIR — Again, to the point Evan was just making, are there barriers that should be addressed in our report to achieving that? What should be our recommendations in relation to moving from the theory to the practice, other than to let you work away in your teams?

Mr THORNLEY — Apart from more money for your research — we already got that part.

Prof. SPANGENBERG — I think that there is a requirement to commission detailed studies associated with the viability of the lignocellulosics sector per se; that is the first point. The second point is there are still technological developments that are required for implementation. In a sense I am saying one is a study, and the second is a requirement for research and development.

The CHAIR — At the moment, who funds the Primary Industries Research Victoria, Bundoora centre, or the Molecular Plant Breeding CRC?

Prof. SPANGENBERG — There is a diversity of funding sources and many of those technologies have been funded through, for example, or were co-funded by, the Grains Research and Development Corporation, by Dairy Australia; the R and D corporations supporting the grains and the pastoral industries. The drivers behind this are establishing sustainability and enhancing productivity of plant-based industries. What we are saying is that there are opportunities for deploying these technologies for an emerging new sector, the bioenergy sector.

The CHAIR — So it is only those two funding sources?

Prof. SPANGENBERG — No, there is also federal funding through the Molecular Plant Breeding CRC itself — the Cooperative Research Centre itself. There is industry funding and the Grains Research and Development Corporation, Dairy Australia, Meat and Livestock Australia, Gardiner foundation and so all R and D corporations — —

The CHAIR — Pardon?

Prof. SPANGENBERG — The Geoffrey Gardiner Dairy Foundation.

The CHAIR — And the State Government does not support this?

Prof. SPANGENBERG — The State Government supports this work, yes, so there is co-investment from the State Government, the Federal Government, R and D corporations and industry. The primary driver for that for today is productivity more from the cropping and animal production, but there are spin-off opportunities for applying these technologies now within a new context, and the new context is cereal straw utilisation created by your energy crisis, not competing for the point of it.

The CHAIR — So do you get any funding from big organisations like Monsanto?

Prof. SPANGENBERG — We have funding as well from industry partners.

The CHAIR — Is Monsanto involved?

Prof. SPANGENBERG — In this particular case Monsanto is not one of the funders, but there are commercial partners. One of those is PGG Wrightson, which is the largest grass seed company in the Southern Hemisphere. It is a partner within the Molecular Plant Breeding CRC associated with herbage quality improvement in forage grasses.

The CHAIR — So after you do all this work, who owns the intellectual property, given that you have such an interesting mix of funding bodies?

Prof. SPANGENBERG — The arrangement in the particular case of, say, the altered lignin grasses and the exploitation rights, there had to be established in a sense a company, which is called Gramina. It is a joint venture between the Molecular Plant Breeding CRC and PGG Wrightson, and that company will capture the value. So in a sense it is a trans-Tasman company, 50 per cent owned by Australia and 50 per cent by New Zealand.

Mr THORNLEY — I am just looking in general at cellulosic ethanol, about which I know almost nothing, but I have heard people discussing it, saying, ‘We can use wheat stalks and we can use this and that’, and then some people talk about some specific crops that may be grown for cellulosic ethanol. I have heard others talk about woodchips and things like that. Your research, I suspect partly for the funding reasons we have outlined here, has focused on grasses. Are they a significantly more likely or more efficient source of cellulosic ethanol, or are things like woodchips an equally likely feedstock?

Prof. SPANGENBERG — Since our work so far has been funded because of the animal industries, we have developed this as a spin-off technology for other applications, and I would see that in a sense we will likely end up with a diversity of feedstocks. They could go from woodchips through to dedicated bioenergy grasses, and the economics will determine which one would be most successful in ensuring that the plants have a continuous supply of feedstock in a sense.

Mr THORNLEY — I guess I am trying to get a sense from you about this. Do you know anything about the economics of those feedstocks relative to each other to get a sense of which one is most attractive for bioethanol?

Prof. SPANGENBERG — I would say actually that perennial grasses, C4 grasses, highly water-use efficient perennials, would be the ones likely to become the preponderant ones in longer term; plus cereal straw, the reason being that straw would be seen as having a waste value today; and in the longer term a perennial grass, particularly, say, one of the C4 grasses that would be highly efficient in biomass production, very water-use efficient and adapted to marginal land, will be the lowest input.

Mr THORNLEY — How does that not compete with food, though? I mean, aren't those also pasture grasses for livestock, so isn't there an alternative form of competition between cellulosic ethanol and food production?

Prof. SPANGENBERG — Yes and no. The talk is about having dedicated bioenergy grasses, and therefore when I make reference here to perennial grasses, for example, you might think about the perennial rye grass, the core grass for the dairy industry today. I am not saying that would be the feedstock. I am saying there would be another grass, and as I say, it would likely be a C4 grass.

Mr THORNLEY — So a phyllurus?

Prof. SPANGENBERG — Or a paspalum or C4 grass. Some of the species that will have potential would be paspalum dilatatum, endoglucanases and brachial species, so one could look at it in a wider context.

Mr CRISP — Your research priority interests me. I think that what you are advocating is that in the pursuit of lignocellulosic ethanol we are going to breed for feedstock, rather than adapt the process for the feedstocks we already have, so that we can get the lignin out of the walls of the feedstock. I presume that if we breed the feedstock, we could use our existing conventional ethanol process, whereas another line of research is to try to develop the enzymes to break down lignin within the structure, so that you can then move in a three-stage process to ethanol. Is that where you are at?

Prof. SPANGENBERG — I think the two things are not mutually exclusive. The last point, which I did not cover, is basically that one could also have the feedstock itself produce the enzyme component required for the degradation. In a sense we start with the lignocellulosic residue, the cellulose that will contribute to the energy. We need to make the cellulose accessible to the fermentation. Today one can try to create a residue from the lignin in having a very inefficient process. If we are talking about making it viable, we have to make every step as efficient as possible. The first step is making the lignocellulosic feedstock as fermentable as possible. The small component in lignocellulosic that makes it inefficient is lignin. So by enhancing fermentability to the more defined lignification of that feedstock we can make that step more efficient. The second one is that once one is fermenting cellulose the most expensive component is the enzyme and one can either produce it in a different system and add it or have the plant itself produce it. Then one would again be having it cheaper. So the research is in all those stages. We are working on the feedstock side.

Mr CRISP — Would producing the enzyme make it co-compatible for animal use as well ethanol?

Prof. SPANGENBERG — Potentially, yes. In this particular case what we are thinking is, for example, the third dot point in slide 28, that covers the production of cellular polysaccharides degrading enzymes in plants. The technology is being researched but is not yet there. One way is optimising the enzyme, and this is happening today, in whatever form one delivers it. Another way is having an optimised enzyme system that the plant produces itself. One of the technical difficulties associated with that is where in the plant to deliver the enzyme — it needs to be done in an inducible form, because you would not like to interfere with normal plant development. There are active researches taking place in this field. It is the cheapest one, because the plant itself is using solar energy for creating the most expensive component in the fermentation part.

Mr CRISP — I guess this is a difficult question, because it has political implications: as so much of this work depends on GM and in our community we are still debating the pros and cons of GM, giving us time to move with our communities, this would have to be many years of research off, would it? Our current state where the communities are with GM, which is generally opposed, is not getting in the way of your research at this stage?

Prof. SPANGENBERG — I would say no. We have a balanced portfolio of activities, but almost half of our research efforts are in GM technology.

Mr CRISP — This is us getting some counsel from you now because when science and public debate get too far apart we get stuck in the middle. I know it is very hard to answer — it is virtually asking how long is a piece of string — but what sort of time frames would the work you have outlined today have on them?

Prof. SPANGENBERG — Not for the bioenergy field of application but just to describe it, we are developing, say, high-energy rye grass for the dairy industry for animal production. The time line for that is five years from now.

Mr CRISP — This would be an additional step that will be beyond that again?

Prof. SPANGENBERG — That would be beyond that, yes. I would say that we are talking about between a five and eight-year time frame.

Mr CRISP — Thank you for being so candid with us, as we on this side of the table work out what all of that means.

Dr KOOPS — Is it going to happen by itself, or do you need a specific research stream looking at the development for ethanol production? Is it going to effectively piggyback on the livestock technologies?

Prof. SPANGENBERG — I think it will benefit from the past investment in that area, but it will not survive because of that only.

Dr KOOPS — Are you at a stage yet where, if additional funds were made available to you start that kind of research soon, you could progress things quicker?

Prof. SPANGENBERG — Yes, absolutely. A specific example. I showed you the legume modification technology in perennial rye grass. We can apply that today for the animal industries. If we want to apply it to cereal straw, we need to do it, and that is not funded today. It is not resourced today.

Dr KOOPS — Would that be a good use of the funds? Among a broad portfolio of things that you would be prioritising for research, would you rate that as a good use of money?

Prof. SPANGENBERG — I would think so. I think that utilising cereal straw, which only has a waste value today, is the best starting point, because we produce it today. I make the case that we do have a technology that should be directly applicable to wheat, but we need to apply it.

Mr CRISP — In respect of that serial straw mass, I come from northern Victoria and very low amounts are left per hectare unless it is a particularly good year because the wheat is always short. One of the concerns I have is that the energy required to collect and transport that off a vast area could well negate the gain.

Prof. SPANGENBERG — I think it would be a combination of both. Of cereal straw, a waste today, plus the bioenergy grass. When I said that it is critical to do the diesel economics, it would depend on the scale of the plant. What is the biomass of this required to be contracted to be fair to that purpose? I would argue that farmers would appreciate having another revenue source from straw. If we look at the harvest index of, say, 50 per cent in the low-rainfall areas in the state, it means that half of what we are producing is biomass that could be utilised for a diversity of fuel, certainly for bioenergy.

The CHAIR — Does your centre do the economics as well, or is that done somewhere else — the economic modelling?

Prof. SPANGENBERG — I was saying that it would be important to a do full economic analysis of this case, and I think the Department of Primary Industries has the capability, as I said, to do that.

The CHAIR — Okay. Again, this might be self-evident to others, but is it important for land that the cereal straw remain on it. You were talking about the fact that the land is often marginal. Stopping erosion or assisting with fertilising or anything like that — has it got any value in that regard?

Prof. SPANGENBERG — Yes, I am studying the association with that. It is desirable to use straw in the context of aspects of soil, architecture and carbon. But there is a limit to that as well.

The CHAIR — Is there?

Prof. SPANGENBERG — Yes. It means that there is straw as genuine waste. Looking at it, a sustainable production system needs to consider and an economic analysis needs to consider the amount of straw that is required to be retained. In the past for many years we have been burning that — for controlling fungi, for example. We have replaced that. If we are doing zero tillage, it is through increased applications of fungicide. There is an economic whole-of-system analysis required.

The CHAIR — Thank you very much. We appreciate your assistance, professor. You will be given a copy of the Hansard transcript for any typographical corrections in about a fortnight.

Prof. SPANGENBERG — Thank you very much for your time.

Committee adjourned.